FIRE HISTORY OF TENDERFOOT CREEK
EXPERIMENTAL FOREST-LEWIS AND CLARK
NATIONAL FOREST

January 1993

FINAL REPORT FOR RESEARCH JOINT VENTURE AGMT
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SYSTEMS FOR ENVIRONMENTAL MANAGEMENT
FS Contact: Dr. W. W. McCaughey
Co-op Contact: Stephen W. Barrett

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Prepared by:
Stephen W. Barrett
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INTRODUCTION

Lodgepole pine (Pinus contorta Dougl. var. latifolia) forests in the northern Rocky Mountains have experienced substantial variation in presettlement fire patterns (Arno 1976, Sneck 1977, Arno 1980, Romme 1982, Romme and Despain 1989, Barrett and Arno 1991, Barrett et al. 1991, Barrett [in prep]). On relatively productive habitat types at lower elevations, short- to moderately long interval (25-150 yr) fires have occurred in a mixed severity pattern ranging from non-lethal underburns to total stand replacement (Arno 1976, Sneck 1977, Barrett and Arno 1991, Barrett et al. 1991). Markedly different fire patterns occurred in high elevation lodgepole pine forests on unproductive sites, such as in Yellowstone National Park. On Yellowstone's infertile subalpine plateau, Romme (1982) and Romme and Despain (1989) found that stand replacing fires recurred after very long intervals (300-400 yr), and that non-lethal surface fires were rare. Barrett (in prep) found a similar fire pattern but substantially shorter intervals on more fertile sites adjacent to the subalpine plateau, in the Absaroka Mountains. Average intervals for stand replacing fires in that area were about 200 years, and Barrett (in prep) concluded that the natural fire pattern was similar to that found in steep mountain terrain in northwestern Montana (Sneck 1977, Barrett et al. 1991).

Previously, little fire history information existed for lodgepole pine forests in mountainous areas of central Montana, such as in the Little Belt Mountains. In 1992 a study was initiated in cooperation with the USDA Forest Service Intermountain Research Station to determine the fire history of the Tenderfoot Creek Experimental Forest (TCEF), Lewis and Clark National Forest (fig. 1). The New Perspectives format of landscape management would utilize these data in evaluating a variety of proposed research projects for TCEF, and the fire history could be a useful interactive component of a Geographic Information System. Primary objectives were to: 1) determine pre-1900 fire

periodicities, severities, and burning patterns in the area's lodgepole pine dominated stands, and 2) document and map the forest age class mosaic, reflecting stand replacing fire history at the landscape level of analysis. Secondary objectives were to interpret the possible effects of long-term fire suppression on area forests, and to determine their relative position along the fire regimes continuum for northern Rockies lodgepole pine.

STUDY AREA

TCEF encompasses approximately 8600 acres of the upper Tenderfoot Creek drainage, ranging in elevation from ~6000 to 7900 feet. The area is primarily a headwaters zone dissected by a primary drainage (Tenderfoot Creek) and 7 subdrainages in a dendritic erosion pattern. Perhaps significant to the fire history, a relatively abrupt change in terrain occurs at about 7000 feet, where the steep narrow canyon drained by Tenderfoot Creek moderates to gentle- or moderately steep slopes approaching main divides. The study area is occupied by single-layer, even-age stands that are dominated by lodgepole pine and occasionally whitebark pine (*P. albicaulis* Engelm.), and most stands have very sparse tree understories of shade tolerant subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.) and Engelmann spruce (*Picea engelmannii* Parry). Throughout the Little Belt Mountains extensive even age classes of lodgepole pine have regenerated shortly after stand replacing fires that exposed mineral soil seedbeds and promoted seedling establishment (Lieberg 1904, Fischer and Clayton 1983). Stands are comparatively slow growing and limited in floristic diversity, with the following habitat types (Pfister et al. 1977) defining potential forest vegetation: 1) *A. lasiocarpa*/*Vaccinium scoparium* (*V. scoparium* phase) on most well drained slopes at mid- to upper elevations in TCEF, 2) *A. lasiocarpa*/*V. globulare* on steep, sheltered slopes primarily at lower- to middle elevations, 3) *A. lasiocarpa*/*Calamogrostis canadensis* in moist

draws, and 4) a minor amount of A. lasiocarpa-P. albicaulis/V. scoparium above ~7800 ft., along the ridgeline bordering the northeastern portion of TCEF. Grass/forb parks also commonly occur in the area, ranging in size from a few acres to several hundred acres.

METHODS

Two research methods (Arno and Sneck 1977, Barrett and Arno 1988) were used in this fire history investigation. Arno and Sneck's (1977) method was used when fire scarred trees were available for sawing partial cross-sections from fire scars. When impacts from chainsawing were not acceptable, such as in the proposed Research Natural Area in the eastern portion of TCEF, an increment borer was used to sample fire scars and stand initiation years (Barrett and Arno 1988). Otherwise, both methods recommend developing a forest age class map (Heinselman 1973, Tande 1979) as a primary basis for interpreting fire history in areas subject to stand replacing fires.

Sample Site Selection. In the office, aerial photographs and a timber type map (1957 and 1963 surveys) were used to draw a preliminary map of stand polygons comprising the forest age class mosaic. This age class map (7.5 minute scale) was used to select sampling transects and any potentially important sample sites. For example, the margins of adjoining even-age classes often yield useful samples because such sites enable documentation of more than one stand-replacing fire (Heinselman 1973, Tande 1979). Finally, a habitat type map was consulted to ensure that the transects would cross a representative array of forest vegetation.

Stand Sampling. In the field, sites were evaluated for sampling by first verifying the existence of fire-initiated even-age classes or fire scarred trees. In stands lacking fire scarred trees, an initiation year for each seral age class was estimated by increment boring the piths of dominant seral trees

one foot above ground line (initiation years approximate actual fire years because most lodgepole pines become established shortly after lethal fire [Brown 1975, Arno and Sneck 1977]). When possible, preliminary ring counts were made in the field to ensure that similar pith years had been obtained from at least 3 trees. When trees also contained datable fire scars, partial or full cross section samples were sawn from the trees (Arno and Sneck 1977), or the scars were sampled with an increment borer (Barrett and Arno 1988).

Postfire tree succession was documented in the sample stands by sampling one or more representative circular macroplots (375 m^2)(Arno and Sneck 1977, Barrett and Arno 1988), depending on stand extent and variability. Stand physical structure was documented by making ocular estimates of tree species canopy coverage according to 4 dbh classes (0-4 in., 4-12 in., 12-30 in., 30+ in.). To complete the sampling of stand age structure, 2 or more of the largest-diameter (dominant) trees within each size class were increment bored, augmenting the tree-age data already taken from the stands' seral age classes.

Age Class/Fire Scar Analysis. In the laboratory, the fire scar partial cross sections and increment cores were surfaced and dated by counting annual rings under magnification. Fire scar years were estimated by making several ring counts from the tree cambium to each fire scar annulus. Similarly aged fire scars that apparently dated to the same event were adjusted to the sample with the clearest ring pattern (Arno and Sneck 1977). For the age class increment cores, estimates were made of the number of additional rings to the pith for any cores that did not precisely intersect tree center. Final estimates of the age class initiation years were made using the following criteria, if more precise evidence from fire atlas records or fire scars was unavailable: 1) similar pith years were required from at least 3 seral trees per age class, 2) 30 years was considered an acceptible range defining a seral age class, and 3) the earliest pith year found among similarly aged dominant

trees was used to designate the initiation year.

Postfire succession was interpreted by constructing stand tables based on the tree macroplot data (Arno and Sneck 1977, Barrett and Arno 1988). Bar graphs were constructed by plotting each tree species' canopy coverage (Y axis) according to the 4 dbh classes (X axis), then labelling the mean tree ages that were obtained from dominant trees in each class. If more than one plot was sampled in a stand, a composite stand graph was constructed by averaging the canopy coverages and mean ages for each species per dbh class. Successional interpretations then were derived by examining the stands' tree structure- and age patterns relative to stand fire history.

Fire Frequency Analysis. Two methods were used to analyze fire frequency. First, all fires detected from sampling and from fire atlas records were listed in an area master fire chronology (Arno and Sneck 1977), allowing calculation of mean frequency for the entire study area. When sample stands produced data from fire-scarred trees, stand master fire chronologies also were compiled. Mean fire interval (MFI) was calculated for stands with evidence of 2 or more intervals by dividing the estimated number of years in the chronology by the number of intervals. When stands did not contain fire scars but had evidence of 2 or more fire initiated age classes, age class chronologies were constructed by estimating the years of successive lethal fires that occurred on the site (Barrett and Arno 1988, Barrett et al. 1991, Barrett [in prep]). First, the most recent fire year was estimated from pith samples of the stand's current seral dominants. Then previous fire years were estimated from pith samples of older seral age classes, for example, from survivors of the most recent fire, or, from fire killed snags. Age class chronologies were used to estimate fire frequency by calculating the approximate number of years between successive fires. MFI was calculated for any sites with evidence of 3 or more fires (i.e., at least 2 complete fire intervals). However, because lodgepole

pine stands rarely produce evidence of more than one fire interval (2 successive fires), the alternative was to calculate a multiple-site average fire interval (MAFI)(Barrett and Arno 1988, Barrett et al. 1991, Barrett [in prep]). MAFI was computed by totalling the single fire intervals derived from sample stands of similar habitat type, then dividing the total number of years by the number of intervals.

Age Class Mapping. A final version of the forest age class map (Heinselman 1973, Tande 1979) was derived by using 4 data sources: 1) samples of fire scars and stand ages, 2) aerial photographs, 3) the timber type map, and 4) fire atlas records for post-1900 fires (on file, Kings Hill Ranger District, Lewis and Clark National Forest). For pre-1900 age classes, the sample locations and stand ages were labelled on the 7.5 minute topographic maps. The preliminary stand margins that had been drawn prior to field sampling were rechecked and edited by examining the sample locations. Unsampled stands were labelled by extrapolating ages from nearby sampled stands of similar crown appearance. After the age class map was edited, acetate overlays were prepared at the 7.5 minute scale, enabling future use with other type maps for research or management purposes.

RESULTS AND DISCUSSION

Landscape Fire Patterns. Sampling at 51 sites (fig. 1) produced 304 age class increment cores, mostly from lodgepole pine. Additionally, 13 partial cross sections were sawn from fire scarred lodgepole- and whitebark pines, and 6 trees were scar bored. The fire scarred trees typically had a single basal fire scar, but a few trees had 2 scars, and most scarred trees were found in the relatively gently sloped uplands or along major ridgelines.

The master fire chronology extends back 412 years, to about 1580 (table 1, fig. 2), and is composed of primarily stand replacing fires that initiated the

current age class mosaic (fig. 3). The increment core- and fire scar data suggested 12 fires between 1580 and 1992, resulting in an MFI of 38 years--that is, stand replacing fires of varying size occurred in the ~8600 acre study area on an average of every 4 decades. The last fire of any significance occurred 45 years ago in 1947 (~20 ac.), and the last major fire occurred 90 years ago, in 1902 (~650 ac.).

The master fire chronology contains 5 major fires (600+ ac.), yielding an area MFI of 103 years for large fires. Together, these 5 fires initiated most of today's age class mosaic: 1726, 1765, 1845, 1873, and 1902 (table 1, figs. 2-3). Additionally, relatively widespread sample locations indicating the oldest fire suggested a possibly major event in about 1580, but subsequent fires destroyed most stands that regenerated shortly after that fire. A paucity of fire scar- and age class data between 1580 and 1726 suggested that either a relatively fire-free interval occurred for ~150 years after 1580, or that a large amount of fire history evidence was destroyed by post-1700 fires (few snags or ridgetop whitebark pines were found dating to the 1600s). After 2 major fires in the 1700s, nearly a century lapsed before major burning recurred in the mid- to late 1800s. Similarly, 9 decades have now passed since TCEF's last major fire. Thus, the average interval between major fires has been relatively long over the past 400 years but the data suggest a repeating cycle of large burns occurring close in time, followed by comparatively long fire-free intervals. The chronology also reveals that about 1 out of every 2 fires burned substantial acreage in TCEF. From a landscape perspective, the overall interpretation is that while few ignitions developed into spreading fires, many fires became important ecological events, often in pulses of activity spanning just a few decades.

Because some major fires after 1726 occurred relatively close in time, age class margins often were indistinct on the aerial photographs (fig. 3). The

grouped nature of major fires in the chronology and on the landscape also suggests that portions of fires might have been reburns (e.g., see juxtaposition of 1726-1765 age classes; and 1845-1873-1902 classes [fig. 3]). Specifically, severe fires can recur in post-fire fuels, primarily dead trees and dense post-fire regeneration, several decades after an initial event (Brown 1975). Lieberg (1904) first alluded to this fire-fuel interaction in his survey of the early-day Little Belt Mountains Forest Reserve, bordering today's TCEF:

> ".... In this region fires almost invariably destroy the forest, except in thin subalpine stands. The timber is rarely consumed by the first fire. Usually it is killed and left standing, and is later overthrown by wind and destroyed by future fires. ....." (Lieberg 1904: 24)

The age class mosaic for TCEF is moderately complex, composed of polygons ranging in size from a few tens of acres to an estimated maximum of 700 acres. A few relatively small polygons are 2-aged, a result of mixed severity underburns, but most stands are 1-aged and cover substantial acreage. For example, the 1873 fire apparently initiated the largest number of seral stands, which occupy an estimated 3000-4000 acres in the central to eastern portion of TCEF (largest polygon: ~700 ac.)(table 1, fig. 3). However, these 1873-initiated stands often abut stands that regenerated after a substantial fire in 1845, making it impossible to accurately estimate fire sizes (fig. 3). Similarly, some of the area's oldest stands, generally north of Tenderfoot Creek, regenerated after fires in 1726 and 1765 and today comprise an indistinct mosaic that totals an estimated ~1500-2000 acres.

In summary of the TCEF forest age class mosaic, most stands regenerated after just 4 fires between 1726 and 1873. Between 75% and 90% of the area is occupied by overmature stands, ranging in age from ~120 to 260 years. The oldest stands, dominated by high elevation whitebark pines or by moist-site

spruce and subalpine fir approaching climax, are between ~310 and 410 years old and comprise less than 2 percent of the mosaic. Conversely, the area's youngest stands today are between 45 and 90 years old and occupy about 8 percent of the age class mosaic.

Stand Fire Patterns. Fire patterns also were examined at the stand level of analysis because most research and management activities occur at that scale. Eighteen sites were used to interpret stand fire history (table 2). Most sites lacked evidence of successive fires and MFIs could be calculated for only 4 stands. These MFIs ranged widely, from 29 to 161 years, and were not meaningful given the scarcity of these data. Alternatively, MAFIs provided useful information about stand fire patterns. In terms of actual stand replacing fires, 10 intervals ranged from 57 to 293 years, and MAFI was 150 years; however, when 18 incomplete intervals representing the current ages of overmature stands were included in the calculations, MAFI increased to 179 years, perhaps more representative of the natural variation in fire frequency. (Given today's relatively old age class mosaic and the paucity of data for actual fire intervals, the 18 incomplete intervals apparently enabled a more complete interpretation regarding stand fire patterns. Note, however, that this method still yields a slightly conservative MAFI, since the eventual fire intervals will be somewhat longer than the incomplete intervals in table 2).

Fire frequencies also were estimated for stands on different terrain to detect any possible differences in historic fire pattern--specifically, moist canyon sites versus the more gently sloped and frequently drier upland sites. Data from 7 relatively moist stands (e.g. Abla/Vagl h.t.), primarily in Tenderfoot Creek canyon, suggested that stand replacement intervals would range from 57 to 421+ years ("+"= an incomplete fire interval), and MAFI was 205 years. Data from 11 dry upland stands (Abla/Vasc h.t.) suggested a range of 105 to 316+ years, and MAFI was 169 years--somewhat shorter because ignitions

on drier sites evidently have more opportunity to develop into spreading fires. For example, converse to upland sites, an overall lack of fire scars and multiple seral age classes in the steep canyon terrain suggested that such sites rarely experienced mixed severity underburns.

The fire scar- and tree plot data provided insight into mixed severity burning (table 2, figs. 4-5), which occasionally occurred in conjuction with total stand replacing runs nearby. Intervals for the mixed severity underburns ranged widely, from 20 to 124 years, but most were between 30 and 50 years long (MAFI: 55 yr). Underburns occurred in 5 of the 11 upland stands in table 2, but in only 1 of the 7 canyon stands--the latter after a long interval of 108 years. Relatively large 1-age stands occupy the steep slopes along lower Tenderfoot Creek canyon, and the few fire scarred trees in that area usually indicated merely a "burn margin" effect (Romme 1982), where a few trees survived at the edges of a stand replacing burn. During a fire, fuels on steep slopes are more prone to pre-heating, contributing to the development of large stand replacing runs. By comparison, stands in the more gently sloped middle- to upper elevations of TCEF sometimes experienced mixed severity fires that occasionally triggered a second age class. The uplands have a somewhat more intricate age class mosaic than the canyon (fig. 3), with relatively smaller age class polygons composed of 1- or 2-aged stands. (One whitebark pine-dominated stand along the high elevation ridgeline had 3 seral age classes [this stand is shown as primarily 2-aged in fig. 3 because the extent of the minor third age class was unclear]). This occasionally complex fire behavior is due in part to interactions between site type, stand fuel structure, gentle slope, and abrupt fuel changes caused by moist seeps or grass-forb parks. Some fires, ignited by lightning or humans (Lieberg 1904), also may have spread into the forest from the adjacent dry parks.

Since most mixed severity fires occurred within 50 years of a previous fire,

the secondary burns undoubtedly were fueled by dense post-fire regeneration and fire-killed trees. In 2-age stands today, the younger age class usually comprises less than 20% of overstory canopy coverage (fig. 5), suggesting a patchy pattern of underburns that had achieved only light- to moderate severity. (One exception would be an intense reburn during severe fire weather; such a fire might totally destroy the immature stand and thus consume all evidence of reburning). Conversely, underburns during later successional stages often were highly patchy because live and dead fuels are very sparse in many overmature stands. Such fires usually scarred few trees and failed to trigger a new seral age class. Overall, however, the predominance of stand replacing fires in TCEF is clearly evident by the age class mosaic, in which less than 5 percent of stands are multi-aged and these polygons generally are less than 100 acres each (fig. 3). Absent a reburn, 2 or 3 centuries can pass before drought, ignition, and stand decadence coincide to fuel another stand replacing fire.

In addition to lightning fires, some early-day fires in the Little Belt Mountains are known to have been caused by humans (Lieberg 1904). Before about 1860, Indians frequently ignited fires to improve game forage and for other purposes (Lieberg 1904, Barrett and Arno 1982, Gruell 1985). Lieberg (1904) felt that such fires also helped perpetuate the area's numerous grassland parks. Subsequently, mining and other settlement activities produced heavy timber cutting in the major drainages, and Lieberg (1904) stated that a number of large fires had originated in the residual slash. Regardless of ignition source, however, most fires in TCEF probably burned in natural fuels because early-day logging was negligible in remote drainages.

The fire history data suggest that TCEF stands have experienced nearly the full range of fire patterns previously documented in Northern Rockies lodgepole pine forests. Evidence of non-lethal or mixed severity fires at less than 50

year intervals also has been found on relatively dry, gently sloped terrain on the Bitterroot National Forest (Arno 1976), in the Bob Marshall Wilderness (Gabriel 1976), in Jasper National Park (Tande 1979), and in Glacier National Park's (USA) North Fork Valley (Barrett et al. 1991). Additionally, the fire patterns that occurred on relatively moist, steep slopes in TCEF were similar to those on comparable terrain elsewhere in the Northern Rockies. For example, underburns were uncommon and intervals between stand replacing fires averaged 150 to 200 years in other lodgepole pine stands in and adjacent to Glacier National Park (USA) (Sneck 1977, Barrett et al. 1991), in Kananaskis Provincial Park (Hawkes 1979), and in the Absaroka Mountains within Yellowstone National Park (Barrett [in prep]). In contrast, some of the region's longest fire intervals have been found on Yellowstone's subalpine plateau, where highly unproductive sites and very slow fuel accretion has delayed fires for 400 years or more (Romme 1982, Romme and Despain 1989).

<u>Fire Suppression History</u>. To derive interpretations about the relative effectiveness of modern fire suppression and its possible influence on forest succession, atlas records (on file, Kings Hill Ranger District) were examined for an approximately 16,000 acre area surrounding 8600 acre TCEF. Comprehensive records from 1920 to 1992 indicated that 19 fires (14 lightning, 5 person-caused) burned a total of less than 100 acres in the analysis area. There was no record of spreading fires in TCEF, but 2 fires in adjacent drainages had achieved appreciable size before they were suppressed (1966: 40 ac., 1984: 11 ac.). Before about 1950, early detection and travel to backcountry fires apparently was relatively inefficient, because the fire history sampling revealed 2 spreading fires that were not recorded in the atlas (table 1, fig. 3). In 1947, an intense stand replacing fire burned about 20 acres in the upper Stringer Creek drainage before expiring (there was no evidence of suppression measures such as firelines or felled trees). In 1921 a

mixed severity underburn, totalling less than 100 acres, occurred in 2 separate locations in TCEF, north and east of Onion Park. King's Hill Ranger District also has archival records dating from 1870 that document the general locations of major fires, but these records fail to list the ca.1873 and 1902 fires that occurred in TCEF (4000+ ac., 650 ac., respectively).

From this evidence, it is difficult to interpret whether fire suppression has had any substantial effect on forest succession in TCEF. At the stand level, several factors suggest that succession has not yet been influenced to any appreciable degree. First, fire suppression apparently has been effective for, at most, only 40 years. In most stands, unnatural succession would not occur over such a short time span, even if a fire interval had been artificially lengthened in a relatively old stand (Romme and Despain 1989, Barrett et al. 1991, Barrett [in prep]). However, succession still would have been altered to some degree if fires had been suppressed, for example, in immature stands that were prone to reburns (e.g., 1902 regenerated stands). Since the majority of fire intervals were relatively long, and were comparable to those found in other studies (Arno 1976, Romme and Despain 1989, Barrett et al. 1991, Barrett [in prep]), fire suppression's effect on succession in individual stands presumably has been minimal to date.

At the landscape level, long-term fire suppression might artificially induce mosaic homogeneity in forests that previously contained a heterogeneous mix of fire-initiated age classes (Romme and Despain 1989, Barrett et al. 1991). A potentially serious implication is that mosaics that age uniformly in the absence of fire could be prone to larger insect or disease epidemics, and unnaturally large fires in the future (Barrett et al. 1991). While no large wildfires have occurred in TCEF in this century, other free-ranging wildfires might well have spread into the Tenderfoot Creek drainage and markedly altered the forest mosaic. Nearly 120 years have passed since the last major fire, and

the master fire chronology contains other evidence of 1 or 2 relatively long fire-free intervals over the last 4 centuries. Currently, as much as 90% of TCEF is occupied by stands that are now well within the past range of stand replacing fire intervals for this forest type (nearly 30% of these stands clearly are approaching the upper threshold of the interval range). Stand decadence was commonly observed during sampling, and stands in adjacent drainages recently experienced a large amount of mortality from a "red belt" effect (20,000 acres) and blowdowns (3000 ac.). Consequently, it is reasonable to conclude that the stage is being set for renewed fire activity in the coming decades.

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Table 1. TCEF master fire chronology, ca.1580 to 1992.

Est. Fire Year[2]	Samples[1] Cores	Scars	Percent of Mosaic[3]
1947	6	1	<1
1921	3	2	<1
1902*	17	1	8
1889	4	1	<1
1882	9	2	<1
1873*	139	11	30-35
1845*	35	2	17-25
1831	20	-	2
1765*	16	1	10-15
1726*	44	-	15-20
1676	5	-	<1
1580	6	-	<1

[1] Age classes determined from increment cores or fire scars.

[2] "*" denotes major stand replacing fires, see fig. 2.

[3] Estimated percent covered by polygons in each age class; if multi-aged, polygon was divided by number of age classes to derive coverage.

Table 2. Fire occurrence data for 18 lodgepole pine dominated stands in TCEF (u=upland sites, c=canyon sites).

Stand No.	Habitat Type[4]	Aspect	Fire Intervals UB[5]	Fire Intervals SR[6]	MFI[7]	Last Fire
1u	Abla/Vasc	SW	80,39,28	147+,227+	49	1845
4u	Abla/Vasc	SW	48	119+	-	1921
6u	Ab-Pial/Vasc	SW	-	197,119+	-	1873
21u	Ab-Pial/Vasc	S	50,39,124	103+,316+,266+	71	1889
31u	Abla/Vasc	S	-	147,119+	-	1873
46u	Abla/Vasc	S	-	137,90	-	1902
47u	Abla/Vasc	SE	-	227+	-	1765
9u	Abla/Caca	SW	-	105,161+	-	1831
25c	Abla/Vasc	NW	-	421+	-	1580
14u	Abla/Vasc	NW	20,37	147+,110+	29	1882
44c	Abla/Caca	NW	-	266+	-	1726
41c	Abla/Vagl	N	-	119,147+	-	1845
48u	Abla/Vagl	NE	29	293,119+	161	1902
51c	Abla/Vagl	N	-	137,90+	-	1902
40c	Abla/Vagl	N	-	266+	-	1726
12u	Abla/Vasc	NW	-	221,45+	-	1947
37c	Abla/Vagl	N	-	57	-	1902
27c	Abla/Vasc	NE	108	227+	-	1873

MAFI for stand replacing fires[8] : 179 yr
MAFI for mixed severity underburns : 55 yr

[4] Acronyms follow Pfister et al. (1977).

[5] Mixed severity underburns.

[6] Stand replacement fires ("+" denotes stand age as of 1992).

[7] Mean fire interval based on complete intervals only.

[8] MAFI based on complete intervals and incomplete intervals in overmature stands.

LIST OF FIGURES

FIG. 1

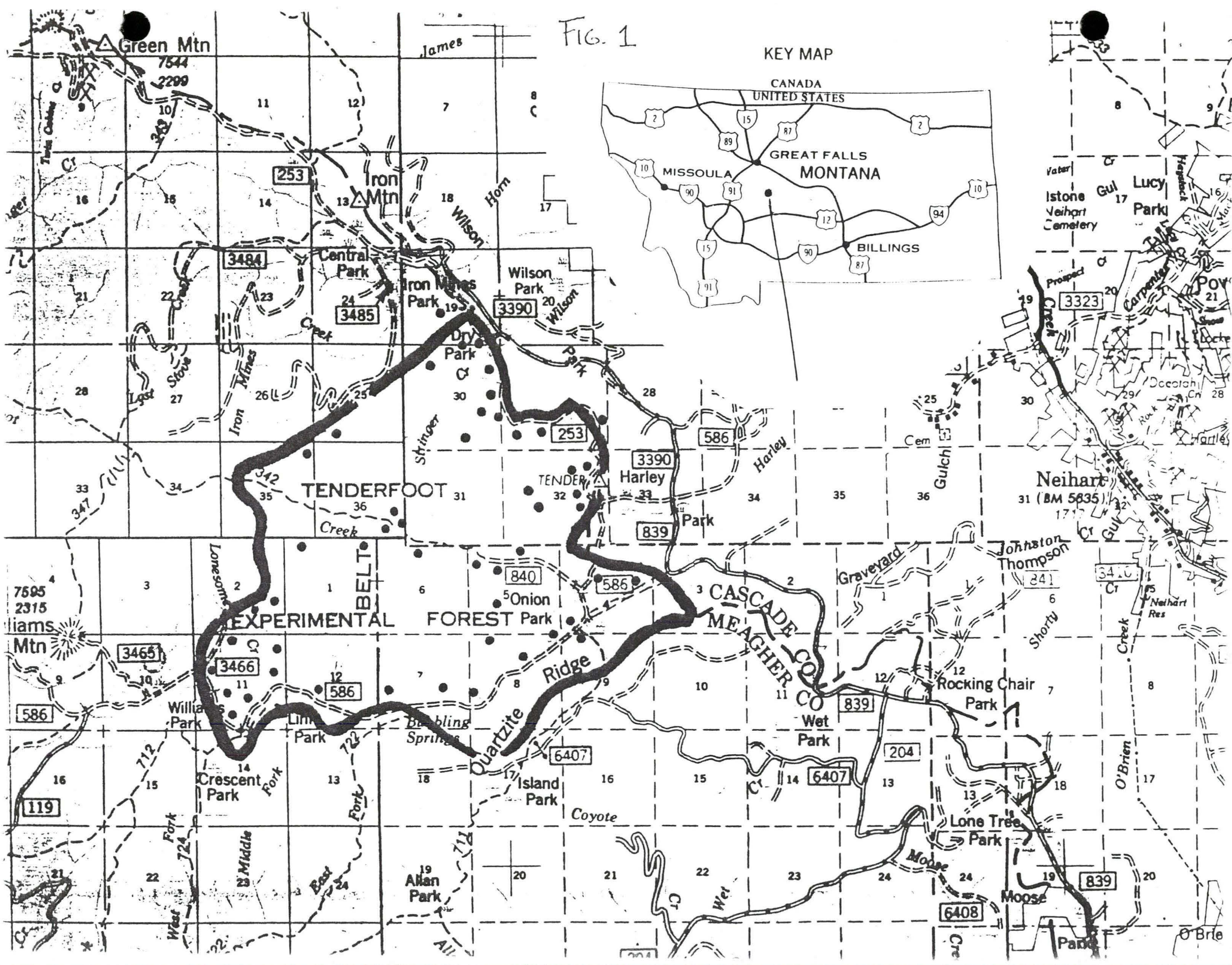

KEY MAP
CANADA
UNITED STATES
GREAT FALLS
MISSOULA
MONTANA
BILLINGS
TENDERFOOT
BELT
EXPERIMENTAL FOREST
CASCADE CO
MEAGHER CO
Green Mtn
Iron Mtn
Central Park
Iron Mines Park
Wilson Park
Dry Park
Harley Park
Onion Park
Quartzite Ridge
Crescent Park
Island Park
Wet Park
Rocking Chair Park
Lone Tree Park
Allan Park
Neihart
Lucy Park
Williams Park
Bubbling Springs
Williams Mtn

FIG. 2

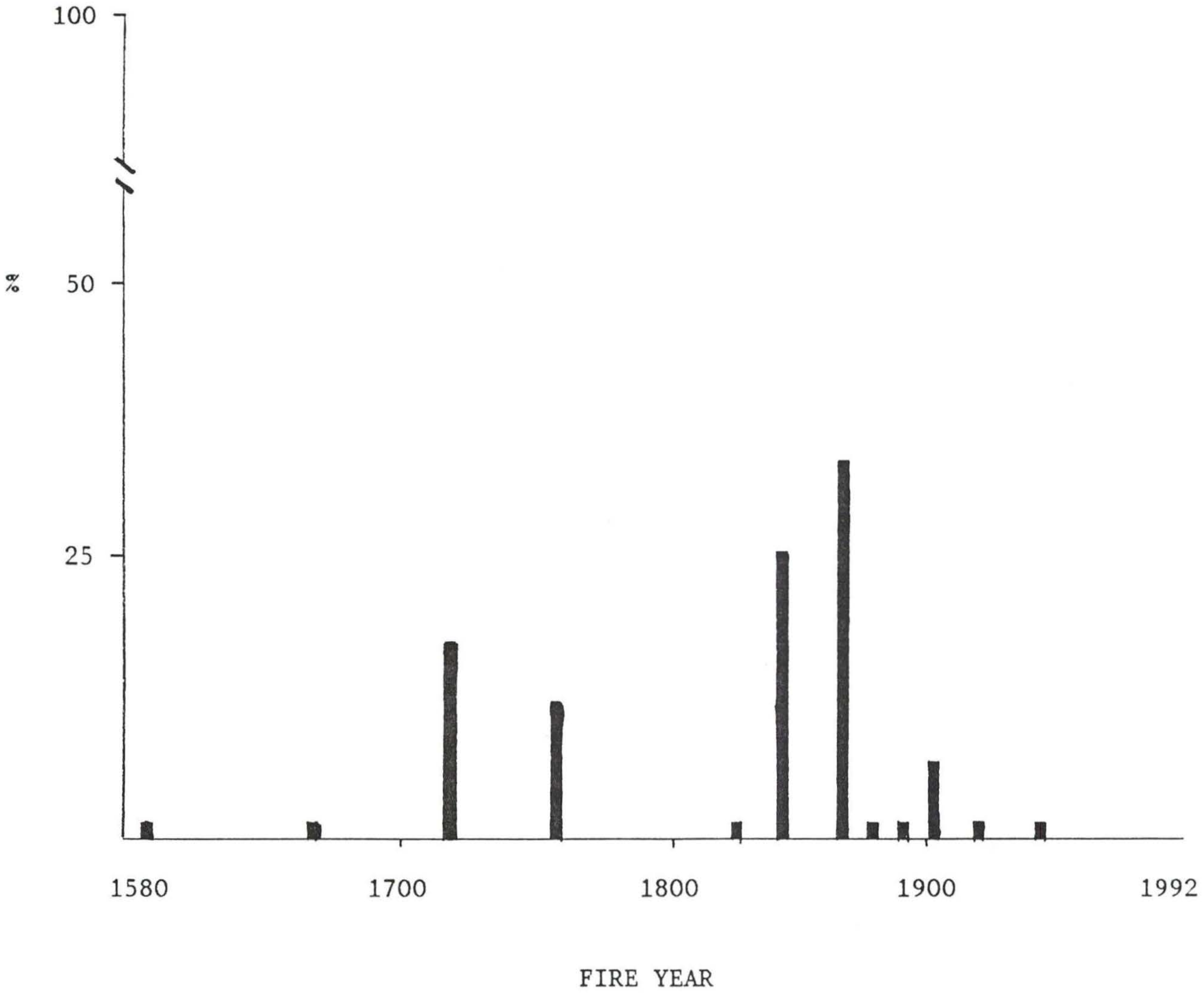


Fig. 3

Fire History: Tenderfoot Cr. Exp. Forest

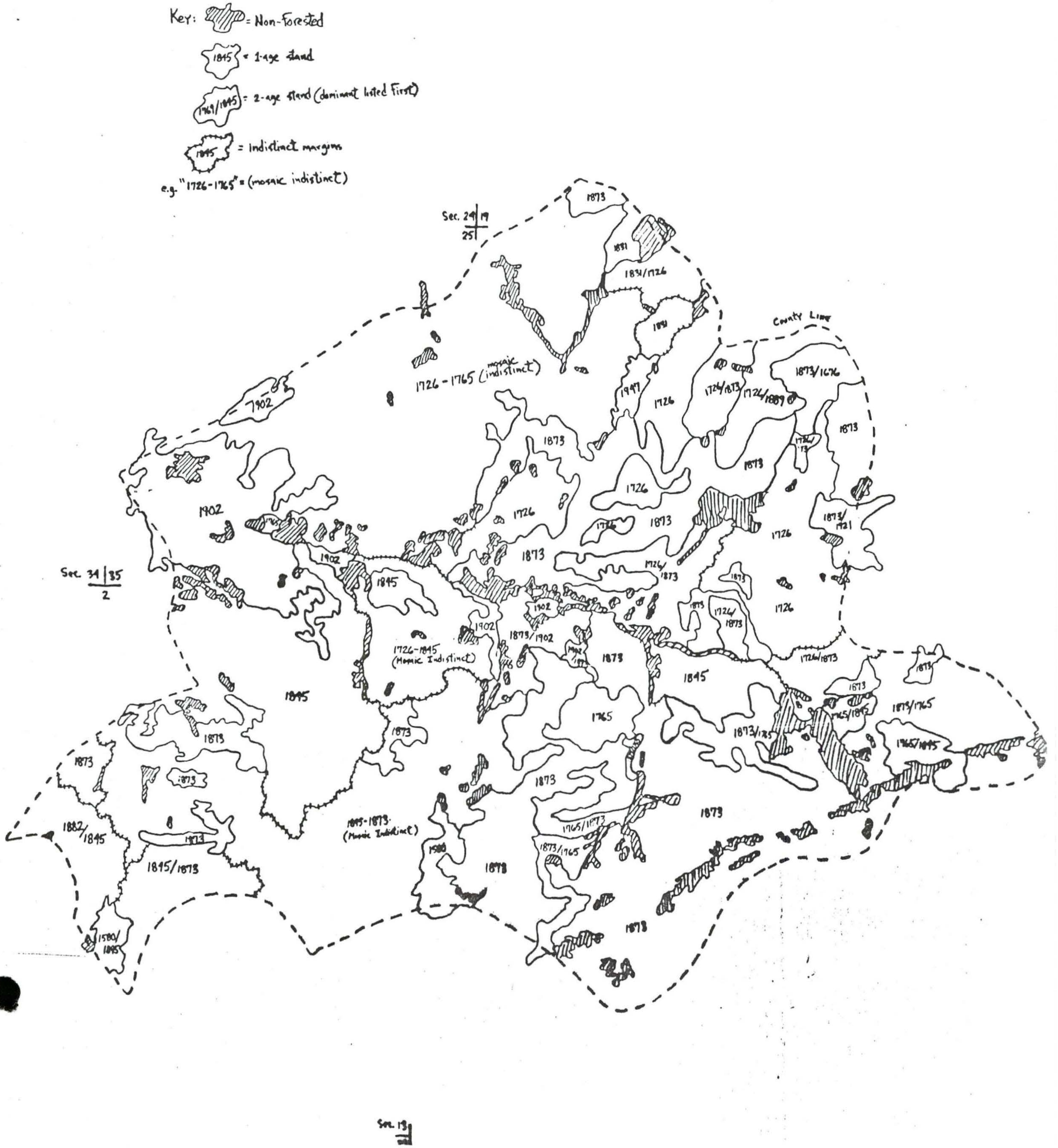


FIG. 4

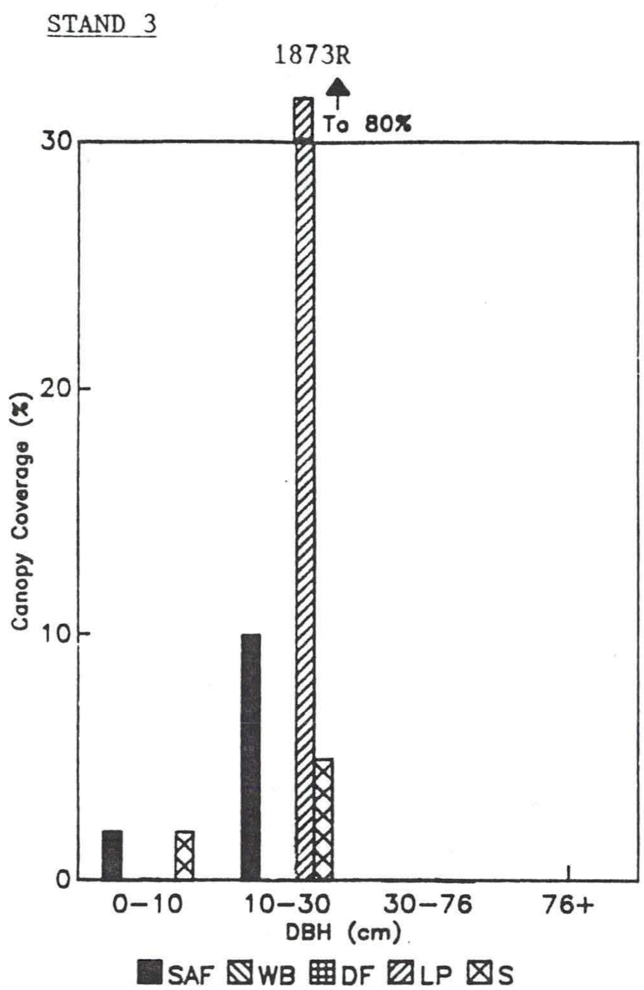
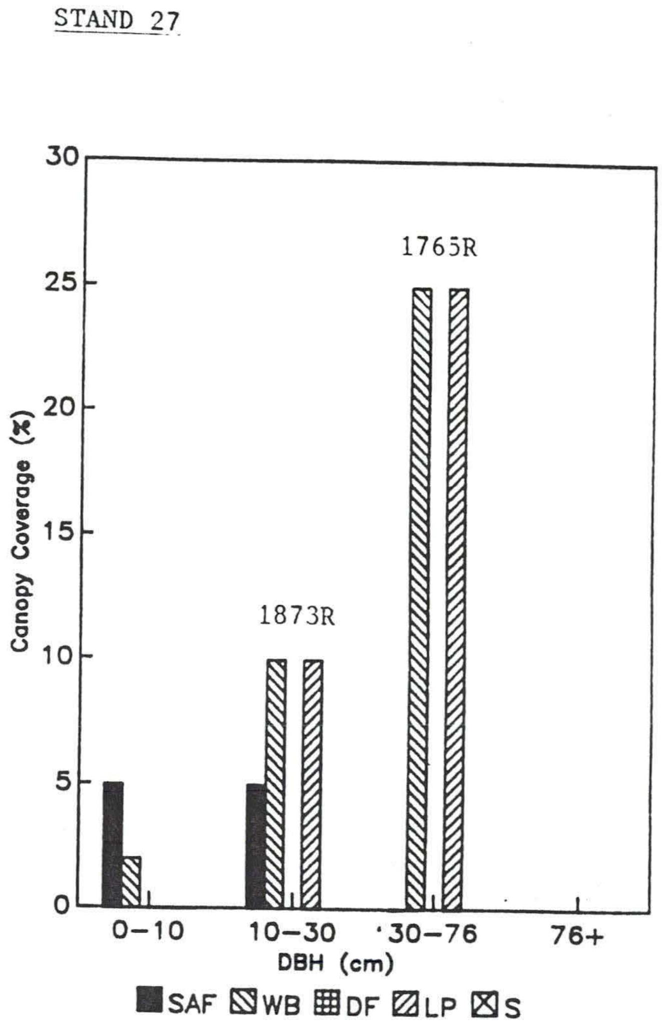

STAND 3
1873R
To 80%
30
20
10
0
Canopy Coverage (%)
0–10
10–30
30–76
76+
DBH (cm)
SAF
WB
DF
LP
S

FIG. 5


STAND 27
1765R
1873R
30
25
20
15
10
5
0
Canopy Coverage (%)
0–10
10–30
30–76
76+
DBH (cm)
SAF
WB
DF
LP
S